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TESTINAL DUPLICATION, CYST-FORMATION  
AND OBSTRUCTION.

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## PERSISTENT OMPHALO-MESENTERIC REMAINS; THEIR IMPORTANCE IN THE CAUSATION OF INTESTINAL DUPLICATION, CYST- FORMATION, AND OBSTRUCTION.

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THE pouch-like formation of intestine occasionally seen projecting from the lower portion of the ileum, is universally known as Meckel's diverticulum. Not that this distinguished anatomist was its discoverer, for early in the eighteenth century Ruysch<sup>1</sup> presents an admirable illustration of this malformation. Its frequent congenital nature was also recognized before the time of Meckel, and it seems probable that suggestions relative to its origin from the vitelline duct had been presented previous to the publications of this investigator. Morgagni<sup>2</sup> says, while speaking of the diverticulum of the ileum: "I have also seen the same appearance more than once in geese, and particularly in one of such a breadth that it could not be taken for the remains of that duct, which has formerly belonged to the vitellum."

Meckel,<sup>3</sup> however, while recognizing that all the better observers have regarded the diverticulum as a congenital malformation of early occurrence, nevertheless maintains that previous to his efforts "there has been no attempt at explaining in what manner this fault of primitive formation arises." We owe to this author not only the almost universal acceptance of his theory of the origin of the pouch in question, but are also indebted to him for calling conspicuous attention to its importance in the causation of serious disease.

Towards the end of the fourth week of the intrauterine life of the human foetus, the primitive intestine communicates with the umbilical vesicle by means of a tube, the vitelline or omphalo-mesenteric duct. During the

<sup>1</sup> Ruysch, Thesaurus Anatomicus, 1701, vii. fig. 283.

<sup>2</sup> Morgagni, The Seats and Causes of Diseases; translated by Alexander, 1769, ii. 141.

<sup>3</sup> Meckel, Reill und Autenrieth's Archiv für die Physiologie, 1809, ix. 428.



subsequent two weeks the abdominal plates close, shutting in a portion of this duct, which, as a delicate thread, unites to the navel the loop of intestine projecting into the depression at the origin of the umbilical cord. During the subsequent development of the intestine, that portion above the insertion of this thread becomes the greater part of the alimentary canal, while from that below this point the lowermost portion of the ileum and the large intestine are developed. The thread usually disappears. With its persistence and growth, however, there remains, more or less permanently attached to the navel from within, a tube, which presents the structure of the intestine, and which may be found patent in the adult, giving rise to an intestinal fistula opening at the umbilicus. The external free surface of this fistulous tract may project as a bulging tumour, with the appearance and structure of mucous membrane. An abundant new-formation of gland-like tissue may arise from its mucous surface, possessing the characteristics of an adenoma of the intestine. There are certain well-recognized variations in the seat, size, and shape of this appendage to the ileum to which attention may here be called.

Since the diverticulum is present, if at all, in the earliest weeks of foetal life it is obvious that its position with reference to the ileo-caecal valve must change with the growth of the intestine. The preponderant elongation of the intestinal tube above the insertion of the duct is accompanied by a less longitudinal growth below this point, and the diverticulum is usually found in the vicinity of the valve. In the new-born child the distance between the two is about 12 inches, while in the adult the diverticulum is found some 3 feet above the ileo-caecal valve. The limits within which it may be present are thus differently stated by various authors. Rokitansky<sup>1</sup> finds its seat to be 1 to 2 feet above the cæcum, while Förster<sup>2</sup> extends the limit to upwards of 4 feet. Klebs,<sup>3</sup> among others, has attributed the origin of a large part of the œsophageal diverticula to congenital anomalies. Although other possibilities than the presence of the vitelline duct exist for irregularities of development in this region, the facts which immediately follow show that the possible presence of the duct at the upper part of the alimentary canal must be admitted as a cause of this diverticulum. For the present this view is satisfactorily disposed of by Zenker,<sup>4</sup> but only from the lack of positive evidence. The possibility is still recognized by him that the œsophageal diverticula of pulsion may proceed from congenital formations.

Meckel<sup>5</sup> states that Lobstein and Wrisberg observed a connection of the

<sup>1</sup> Rokitansky, Lehrbuch der Pathologischen Anatomie, 1861, 3te Auflage, iii. 182.

<sup>2</sup> Förster, Handbuch der Pathologischen Anatomie, 1863, 2te Auflage, ii. 97.

<sup>3</sup> Klebs, Handbuch der Pathologischen Anatomie, 1869, i. 163.

<sup>4</sup> Zenker, Ziemssen's Handbuch der Speciellen Pathologie und Therapie, 1877, vii. Anhang, 61.

<sup>5</sup> Meckel, Beiträge zur vergleichenden Anatomie, 1808, i. 93.

vitelline duct with the duodenum. Major<sup>1</sup> describes a diverticulum which arose from the jejunum, and which contained valvulae conniventes for a short distance from its origin. One, 7 inches in length, has been found<sup>2</sup> on the border-line, between the jejunum and the ileum. Fagge<sup>3</sup> refers to a diverticulum, in the museum of Guy's Hospital, which was 54 inches from the caecum; and to another which arose above the middle of the ileum.

In his comprehensive and valuable paper on intestinal obstruction, Leichtenstern<sup>4</sup> calls attention to the above cases. He says: "The presence of the diverticulum so high up in the intestine, a matter already doubted, is to be understood from the manner of development of the latter. If the growth of the anterior leg of the middle loop is delayed for any reason, the greater part of the small intestine is formed from the posterior or lower leg. In such a case the diverticulum should be found abnormally high."

A similar method of reasoning would permit the development of the diverticulum unusually low down, and it has been suggested by Dr. Symington, in a connection with a case of double cæcum reported by Mr. Lockwood,<sup>5</sup> that the malformation in question might be regarded as a diverticulum.

To these differences in the longitudinal position of the diverticulum may be added the striking deviations in the length of the latter. Although this is commonly found to be less than 4 inches, Rokitansky<sup>6</sup> assigns a maximum of 10 inches. Diverticula, as usually understood, of this length are to be regarded as of extreme rarity. Attention has already been called to one of 7 inches, and Haller<sup>7</sup> refers to a statement by Cocchi that he saw a diverticulum 8 inches in length. It is possible that this unusual length is allowed in virtue of the translation of *digitus*, which may be rendered 6 inches or 8 inches. The greatest length recognized by Rokitansky may be exceeded, however, provided it is admitted that duplication of the bowel is due to the persistence of the omphalo-mesenteric duct.

Occasional rare instances of duplication of the intestine are to be met with in medical literature, and are recorded as present at various portions of the intestinal canal.

Meckel<sup>8</sup> refers to the observation by Blasius of a duplication of the

<sup>1</sup> Major, *The Lancet*, 1839-40, i. 362.

<sup>2</sup> Aerztlicher Bericht aus dem k. k. allgemeinen Krankenhouse zu Wien, Civil Jahr, 1862, 221.

<sup>3</sup> Fagge, *Guy's Hospital Reports*, 3d Series, 1869, xiv. 359.

<sup>4</sup> Leichtenstern, *Ziemssen's Handbuch der Speciellen Pathologie und Therapie*, 1876, vii. 2, 421.

<sup>5</sup> Lockwood, *British Medical Journal*, 1882, ii. 574.

<sup>6</sup> Rokitansky, *op. cit.* 182.

<sup>7</sup> Haller, *Elementa Physiologiae Corporis Humani*, 1778, vii. 97.

<sup>8</sup> Meckel, *Tabulæ Anatomico-Pathologicæ*, 1822. Fasc. iii. 5.

œsophagus in an infant five years of age, extending from the first to the sixth rib. The two portions then united and were continued to the stomach as a single tube.

It is stated by Habershon<sup>1</sup> that "in a cyclopean monster, in which the viscera of a double fœtus existed in a single peritoneal cavity, a double œsophagus was found united in a single stomach, with a large convexity extending from side to side, and giving rise to a single duodenum, placed vertically, and receiving the biliary and pancreatic ducts on either side."

The earliest recorded case of duplication of the duodenum occurred in an infant who lived seven days, and is described by Calder<sup>2</sup> as follows:—

"The Stomach was in a good Condition, but the *Pylorus* was very hard, and felt as if it contained some other Substance which appeared on opening this inferior Orifice of the Stomach to be a glandular Piece of solid Flesh, so closely adhering to the *Pylorus* all round, that there was no separating of it, and without the least Perforation in it anywhere; so that the Passage was quite shut up. Below this the *Duodenum* was divided into two; and the Gut continued thus divided to about one-third of an Inch above the *Jejunum*. Into the largest of these Intestinula the biliary Duct opened."

Fairland<sup>3</sup> describes and figures a specimen of duplication of the intestine found in the body of a male infant at full term, who was operated upon for imperforate anus. The bifurcation began an inch and a half below the pylorus. The small intestine was one-third of an inch in diameter, and contained semi-so id greenish meconium.

"It was tightly filled with this matter as far as the rudimentary cæcum with its distinct vermiciform appendix, from which continued a pipe-like portion of the gut terminating at the cul-de-sac forming the rectum.

"The second portion of the intestine was altogether larger, and more closely resembled a normal bowel; it was about thirteen inches long and one inch in diameter. Before the operation it was distended with fluid, and had been the only portion of the bowel patent since birth. But it terminated in a cul-de-sac and formed, therefore, a species of pouch from which there was no exit except by regurgitation."

It is a noteworthy fact that there are no recorded instances of duplication of the small intestine, with the above exceptions, until the region of the ileo-cæcal valve is reached. This omission is obviously attributable to the description of such malformations as examples of the abnormal insertion of Meckel's diverticulum.

Meckel<sup>4</sup> figures a specimen of duplication of the lowermost end of the ileum, which is described as "divided by a longitudinal septum before the bifurcation," each portion terminating in a cæcal pouch.

The inspection of the drawing suggests, what strangely enough appears to have escaped Meckel's observation, that the specimen was one of vitelline diverticulum with a rudimentary and imperforate colon. The explanation

<sup>1</sup> Habershon, Pathological and Practical Observations on Diseases of the Alimentary Canal, etc., 1859, 124.

<sup>2</sup> Calder, Medical Essays and Observations, Revised and Published by a Society in Edinburgh, 1733, i. 205.

<sup>3</sup> Fairland, The British Medical Journal, 1879, i. 851.

<sup>4</sup> Meckel, Tabulæ Anatomico-Pathologicae, 1822, iii. 23.

of the probable origin of the longitudinal septum will be evident from what is to follow concerning the lateral insertion of the diverticulum. Meckel refers in the text explanatory of this figure to the observation of a similar case by Boerhaave. He, also, reproduces in the same plate a drawing from Fleischmann, to which he applies the term double cæcum; the single colon terminates in a blind pouch. Reference is also directed to cases of a similar character.

Andral<sup>1</sup> alludes to a case mentioned by Brugnoni, in which two colons sprang from a single cæcum and reunited at the rectum.

Somewhat resembling this is the congenital partial duplication of the colon described by Scheiber.<sup>2</sup> The cæcum and ascending colon were widely dilated and in the normal position. Just above the ileo-cæcal valve, the ascending colon divided into two tubes of unequal width, which, diverging somewhat, eventually became united into a single colon.

Still another specimen of similar nature is described by Lockwood.<sup>3</sup> The case was one of intestinal obstruction in a man 57 years of age. The cæcum lay in the right hypochondrium beneath the liver.

"The ascending colon was double; the two tubes were upon the same plane, the smaller one nearer the vertebral column. Each possessed appendices epiploicæ. The tube which was nearest the spine had a very small canal in its centre, which appeared to have a mucous lining. This canal opened above into the colon by means of a small aperture; below it was lost in a mass of malignant disease. It contained no feces. Its walls were moderately thick. The malignant mass which received the end of the diverticulum also concealed the end of the outer tube, which was the colon proper."

It is of this specimen that Dr. Symington<sup>4</sup> suggested that one of the two tubes might be a diverticulum, there being no proof that they united below.

The view—that most, if not all well-authenticated instances of duplication of the intestinal tract, at any part of its course, are the probable result of the persistence and growth of remains of the vitelline duct—is rendered highly probable from what is known concerning the development of the intestine. The thoracic and abdominal cavities are not differentiated at that period in foetal life when the vitelline duct is present. The seat of the latter high up or low down in the foetus would satisfactorily account for the various places of origin of the duplication in question, as it does for those of the diverticulum.

It has already been made apparent that the latter may arise at any point between the pylorus and the cæcum. Whether the duplication or the diverticulum is to result, depends presumably on the existence of

<sup>1</sup> Andral, A Treatise on Pathological Anatomy. Translated by Townsend and West, 1831, ii. 159.

<sup>2</sup> Scheiber, Oesterreichische med. Jarhbücher, Heft 2. Jahresbericht von Virchow und Hirsch, 1875, i. 339.

<sup>3</sup> Lockwood, The British Medical Journal, 1882, ii. 574.

<sup>4</sup> Lockwood's specimen.

conditions favouring or checking the growth of the intestinal walls. The duplication is thus to be regarded merely as an elongated diverticulum, and, like the latter, as will be shown later, may lie within as well as outside the mesentery.

The occurrence of duplication of the oesophagus even may be similarly explained. The evidence is stronger than that offered as explanatory of the origin of the diverticulum of the oesophagus, from the fact that the beginning of the duplication in Blasius's case was lower than the usual seat of the diverticulum. Although in most instances of double intestine the cavities of the tubes are continuous only at their origin, it is obvious that a second communication, lower down, may become established. The manner in which this may take place is suggested by Grawitz<sup>1</sup> in his consideration of a specimen of diverticulum (not of vitelline origin) of the ascending colon. The diverticulum, 8 inches long, consisted of a loop of the colon, the approximated walls of which were fused at the origin, but were separate lower down where the legs were distinct. The fused wall was perforated in two places, while the bend of the loop was closed internally by a septum. Its origin was considered to be foetal, and the result of an imperforate colon forced into a loop-formation from the pressure of meconium from above. With the occurrence of ulceration and adhesions followed by perforation of the fused wall, the intestinal canal might become pervious. This view was favoured by the appropriate presence of cicatricial tissue and deformity. Such a restoration of the intestinal canal could only take place between the fifth month, when meconium is first found in the intestine, and the eighth day after birth, the latter date representing the limit of life in an infant with imperforate intestine.

This interpretation of the origin of a second communication is applicable to all cases of duplication below the stomach, in that part of the intestinal tract where the retention of considerable quantities of meconium is possible. The eventual fusion of the two branches of the oesophagus, as recorded by Blasius, may be similarly explained, from the effects of the retention of food; the time of perforative communication would then take place during some part of the five years of life assigned to the child. The appearance of the drawing reproduced by Meckel and Förster is not in harmony with the inflammatory origin of the inferior communication, but neither of these observers appears to have personally examined the original specimen.

Not only is the difference in the longitudinal position of the diverticulum of importance in connection with its subsequent history, but the fact of its lateral variation should also be borne in mind. All the authorities call attention to its usual origin from the convex border of the intestine. The instances are not a few, however, in which the side of the intestine, even the immediate vicinity of the mesenteric attachment, is the starting-point.

<sup>1</sup> Grawitz, Virchow's Archiv, 1876, lxviii. 506.

In such cases the diverticulum usually has a well-marked mesentery of its own, which is generally described as sickle-shaped. In the Warren Museum of the Harvard Medical School is a specimen of this nature, of additional interest as presenting a branch of the mesenteric artery of considerable size which lies just below and within the free edge of the mesentery of the diverticulum.

In the collection of the Boston Society for Medical Improvement, now transferred to the Harvard Medical School, is a specimen, No. 1808, described in the catalogue as "fœtal diverticulum." It is a dried specimen,  $1\frac{1}{2}$  inch long, arising from the convexity of the intestine, and for two-thirds its length runs parallel with the bowel, and appears to be covered by the same peritoneal envelope. In the same collection is still another, No. 1313, described<sup>1</sup> as follows:—

"Diverticulum: a portion of the intestine of an adult distended and dried. Portion from which the div. arises is largest. Div. is nearly 2 inches in length; about the size of the thumb at origin; tapers to size of tip of little finger, the very extremity again bulges."

The point of interest, at present, lies in the fact that this specimen, like its predecessor, arises free from the mesenteric insertion, and for half its length is firmly attached to the surface of the ileum, being contained within a common peritoneal investment.

Klebs<sup>2</sup> describes a diverticulum, 2 inches long, the half of which lay between the muscular coats of the intestine. It is evident that the case of double cæcum recorded by Meckel<sup>3</sup> belongs in this series.

Roth<sup>4</sup> describes and figures a sausage-shaped diverticulum found in the body of a new-born child. It was  $15\frac{1}{2}$  inches above the ileo-cæcal valve, and ran for 4 inches along the convex border of the ileum within the mesentery.

Specimen 732<sup>2</sup> of the Warren Museum is one of intra-mesenteric duplication of the intestine, and is unique in presenting in a striking manner both these features of irregular development of the intestinal tract.

The specimen was presented by Dr. Joseph Stedman, of Jamaica Plain, Mass., and came from a child eight to ten months old. His recollection of the case, after an interval of several years, permits him to state that the child had been previously well, but was suffering from symptoms of intestinal obstruction, which continued for four or five days. The appearance of the specimen is well shown in the accompanying drawing made by Dr. H. P. Quincy:—

Two more or less parallel intestinal tubes, cut transversely across in their continuity, are contained within a single mesentery. The bloodves-

<sup>1</sup> MS. Catalogue of the Anatomical Museum of the Boston Society for Medical Improvement.

<sup>2</sup> Klebs, op. cit., i. 206.

<sup>3</sup> See note 4, page 4.

<sup>4</sup> Roth, Virchow's Archiv, 1881, lxxxvi. 377.

sels of the latter terminate in the wall of the outermost tube, first supplying branches to the inner tube. The diameter of the outer tube is relatively uniform throughout, while that of the inner, in general somewhat narrower, becomes dilated in the immediate vicinity of an opening through which the canals of the tubes communicate with each other. The contiguous portions of the walls of the two tubes are in close proximity to each other throughout the greater part of their course, and are fused near the common opening.

The walls are composed of mucous, muscular, and peritoneal coats. The mucous membrane of the outer tube shows slightly projecting transverse folds in the vicinity of the opening, while that of the inner tube is relatively smooth. Villi and crypts are present in both.

The opening between the tubes is rounded, sharply defined, one-third of an inch in diameter, and appears to be covered with mucous membrane. The canal of the inner tube is contracted in the immediate vicinity of the opening, and its wall at this part is thickened and fibrous.

Although the most satisfactory explanation of the origin of this specimen is based upon its representing an intra-mesenteric diverticulum, its bifurcated shape, and the seat of the constriction and dilatation require special consideration. Diverticula with knobbed ends are frequently met with, and the rounded ends may have secondary bulgings of their surface. In the Improvement Collection, No. 1033, is a diverticulum with two rounded bulgings at its free end, large enough to suggest an incipient bifurcation.

Hyrtl<sup>1</sup> says that branched diverticula are extremely rare, but he has seen one, an inch in length, coming from a hemicephalic monstrosity, which was divided into five parts.

It is difficult to explain the dilated portion of the inner tube, unless it be assumed that a communication existed between this portion of the tube and the intestinal canal nearer the stomach. There are no instances of double true diverticula.

It is, however, conceivable that the inner tube formed a circle either wholly or partially within the mesentery, and ended blindly in the immediate vicinity of its origin after completing the circle. A communication might eventually be established between the blind end and the beginning of the tube by means of a perforative ulceration.

That the latter process is not unlikely to have taken place is favoured by the presence of the thickened, indurated, and constricted wall at this part of its course.

In the valuable and suggestive article by Roth<sup>2</sup> on the malformations occurring in the region of the omphalo-mesenteric duct, attention is called to the origin of retention-cysts from Meckel's diverticulum. Such cysts are divided into two classes, according as their cavity is continuous or discontinuous with that of the intestine. The wall is composed of the various layers found in the intestine, and the contents are a fluid of various colour

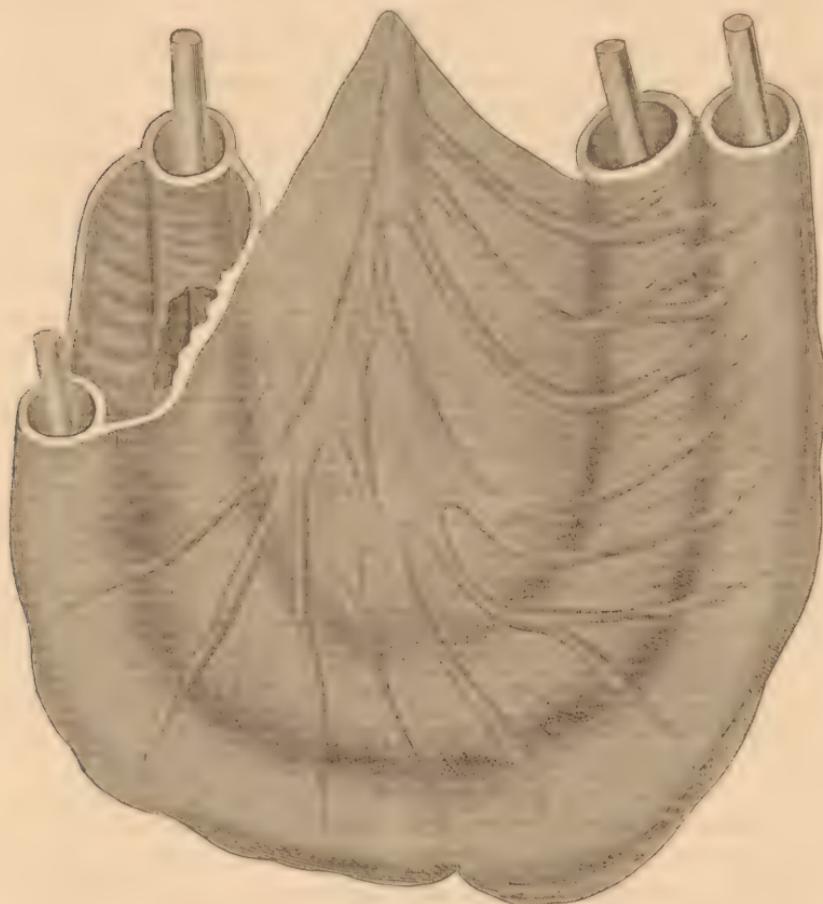
<sup>1</sup> Hyrtl, *Handbuch der Topographischen Anatomie*, 1860, i. 642.

<sup>2</sup> Loc. cit.

and consistency. In both respects the condition is like that occasionally observed in the vermiciform appendage.

The occurrence of the first series of cysts is illustrated by the observation of Tiedemann,<sup>1</sup> who found in a foetus at full term a pedunculate, pear-

Fig. 1.



shaped cyst attached to the convexity of the intestine. It was  $14\frac{1}{2}$  lines long, and 7 lines wide. Its cavity communicated with that of the intestine by means of a canal in the pedicle large enough to admit a probe. The contents were a whitish-yellow fluid, containing several floeculi resembling clotted albumen. Roth<sup>2</sup> contributes the description of a like cyst, somewhat larger, occurring in a child one year and four months old. It was connected with the concave surface of the ileum, near the mesenteric insertion, 26 inches above the ileo-caecal valve. The pedicle having

<sup>1</sup> Tiedemann, *Anatomie der Kopflosen Missgeburen*, 1813, 66.

<sup>2</sup> Loc. cit., 374.

become twisted a hemorrhagic infiltration and necrosis of the mucous membrane had occurred, also acute peritonitis.

These are the only well-authenticated cases of extreme cystic dilatation of the diverticulum known to Roth. Occasional instances of globular forms of diverticula, with more or less constricted necks, are to be met with in medical literature, but none with such extreme constriction as to suggest the application of the term cyst.

Even if the degree of constriction of the neck and the associated distension of the diverticulum present the external appearance of a cyst, the contents are not liquid. Houston,<sup>1</sup> for instance, describes a specimen where the diverticulum formed a circumscripted bag of the size of a turkey's egg, the contents of which were solid, apparently hardened feces.

There can be no question as to the exactness of the term cyst in the second of the series established by Roth where the cavity of the sac is discontinuous with that of the intestine. The earliest observation of this malformation known to him is that described by Raesfeld in 1852, occurring in the body of a new-born child. The cyst was connected with the free surface of the intestine.

The second indisputable observation to be found in print is that published by Roth. At the distal end of the intra-mesenteric diverticulum, already<sup>2</sup> referred to, a cyst was seen, the size of a bean, also lying within the mesentery. The contents were a tough, viscid material, and the walls corresponded with that of the intestine. The epithelial lining was composed of cylindrical cells with and without ciliae. Other cysts, retro-peritoneal and mediastinal, with a wall resembling that of the intestine, were found in the same infant. They were considered as representing lateral deviations from the duodenum and œsophagus, with subsequent detachment, or separated and displaced portions of a diverticulum, or vitelline duct.

Hennig<sup>3</sup> reports the case of an abdominal cyst, in size best comparable to the moderately filled stomach of an adult. It occurred in a new-born child, and filled the anterior portion of the abdomen. The sac measured  $8\frac{1}{2}$  inches by  $5\frac{1}{2}$  inches by 4 inches, lay within the mesentery, and did not communicate with the intestine. It held 100 grammes of clear, pale red, somewhat viscid, slimy fluid; its walls contained intestinal glands, and was covered with cylindrical epithelium. In suggesting the probable origin of this cyst from a diverticulum, it is considered that a shrinkage of the mesentery of the latter may have taken place, with a consequent traction of the end of the diverticulum towards the root of the mesentery, and eventually between its layers. The communication between the intestine and diverticulum is regarded as subsequently obliterated.

<sup>1</sup> Houston, Descriptive Catalogue of the Preparations in the Museum of the Royal College of Surgeons in Ireland, 1834, i. 38.

<sup>2</sup> See note 4, p. 7.

<sup>3</sup> Hennig, Centralblatt für Gynäkologie, 1880, iv. 398.

In the Warren Museum, specimen No. 4903 has the following record in the MSS. Catalogue :—

"Diverticulum from the small intestine. The specimen was obtained at the autopsy, from a patient who died of chronic pleurisy. There were no symptoms during life to call attention to its existence. It was given off from the small intestine about 1 metre above the ileo-caecal valve. It is 3 cm. in length, and about 1 cm. in diameter. There is no apparent communication with the lumen of the intestine."

This specimen is a cyst of the diverticulum, the origin of which is near the mesenteric attachment. Its wall consists of a peritoneal envelope, with loose subperitoneal connective tissue, both continued directly from the intestine. There is a dense middle coat, resembling in appearance the muscular layer of the intestine, although elongated nuclei were not to be made out. Finally, an inner membranous lining, upon the free surface of which occasional club-shaped, stunted villi were found to project. Pouch-shaped depressions, with circular openings upon the free surface, were found scattered throughout this membrane. Epithelium was not present. The middle and internal coats were in the closest proximity to the corresponding layers of the ileum.

Sänger and Klopp<sup>1</sup> describe the presence of five cysts in the abdomen of an infant, the largest of the size of a child's head. The structure of the wall of three of these resembled that of the intestine, and they lay behind the duodenum. In the wall of several of these cysts were islets of hepatic tissue. The cysts were regarded as constricted lateral deviations of the foetal intestine, arising from the duodenal portion in the region where the development of the liver normally takes place. It is a matter of easy inference, however, to regard at least one of these cysts, not containing hepatic tissue in its wall, as of diverticular origin.

The occurrence of simple cysts of possible intestinal origin is not limited to the abdominal cavity.

A cyst in the vicinity of the oesophagus is reported by Wyss.<sup>2</sup> It was of the size of an apple, and was seated on the posterior wall of the oesophagus  $1\frac{1}{2}$  inch above the cardia. The contents were a tough mucus in which were cells of ciliated epithelium. The wall contained muscle as well as fibrous tissue. There was no apparent communication between the cavity of the cyst and that of the oesophagus. The origin of this cyst was attributed to the early detachment of foetal structures, in accordance with the view advanced by Friedreich<sup>3</sup> and Eberth<sup>4</sup> concerning the origin of hepatic cysts with ciliated epithelium from the detachment of bile ducts.

Roth and Hennig<sup>5</sup> report the occurrence of cysts in the vicinity of the

<sup>1</sup> Sänger und Klopp, Archiv für Gynäkologie, 1880, xvi. 415.

<sup>2</sup> Wyss, Virchow's Archiv, 1870, li. 144.

<sup>3</sup> Friedreich, Virchow's Archiv, 1857, xi. 466.

<sup>4</sup> Eberth, Virchow's Archiv, 1866, xxv. 478.

<sup>5</sup> Loc. cit.

œsophagus. In each instance the wall was lined with cylindrical epithelium. In the case reported by Roth the wall had the structure of the intestine, with a predominant development of muscular tissue. The possibility of the origin of these cysts from a diverticulum is to be recognized from what has already been stated with reference to the longitudinal differences in the place of insertion of the vitelline duct. Hennig attributes the origin of the cyst reported by him, which was between the third and fifth cervical vertebrae, to the persistence of a portion of the branchial fissure.

Cysts with a structure resembling that of the intestine are sometimes to be met with in the abdominal wall, in the vicinity of the umbilicus. Their presence in this region suggests at once their origin from a portion of the vitelline duct included within the abdominal wall. The same statement applies to the origin of the adenomata of the navel, described by Küstner.<sup>1</sup> The evidence presented lacks the clinching fact, however, since the reported instances of the cysts and the growths occurred in individuals living at the dates of observation, and there is no evidence to show the relation between the intestine and the posterior surface of the abdominal wall.

Roser<sup>2</sup> reports the case of a male patient, said to have had a tumour in the region of the navel, which had been opened. A slimy, watery discharge from the opening followed the operation, and relief from the fistula was desired. A sound entered a spacious cavity about 6 cm. in diameter. The discharge contained cylindrical epithelium. An incision through the skin disclosed a wall of dense fibrous tissue. When this was cut through there appeared a cavity lined with mucous membrane. As much of the latter as possible was removed, and on examination was found to contain Lieberkühn's glands. Healing, with the formation of a scar, took place after forty-eight days.

A cyst of the abdominal wall an inch above the navel is reported by Wyss.<sup>3</sup> It was of the size of a bean, and lay between the muscle and peritoneum. The contents were an opaque viscid mucus, and its wall, composed of dense fibrous tissue, was lined with ciliated epithelium. If this cyst were of vitelline origin, as its situation suggests, the inclusion is likely to have taken place at an early period of fetal life.

The presence of ciliated epithelium in the primitive intestine is evident from the investigations of Neumann and Kölliker,<sup>4</sup> and its existence in intestinal cysts has already been mentioned.

The clinical importance of these intestinal cysts obviously depends upon

<sup>1</sup> Küstner, *Virchow's Archiv*, 1877, Ixix. 286.

<sup>2</sup> Roser, *Archiv für klinische Chirurgie*, 1876, xx. 475.

<sup>3</sup> Wyss, *loc cit.*, 148.

<sup>4</sup> Kölliker, *Entwickelungs-geschichte des Menschen und der Höheren Thiere*, 1879, 853.

their size and situation. Large abdominal cysts may interfere with the birth of the child, as in Hennig's case, and that reported by Sänger and Klopp. Although the actual cyst or cysts in each instance were not the sole cause of obstructed labour, for an associated ascites was present, they were an important element. In Hennig's case, puncture of the abdominal cavity was necessary before the child could be delivered, and some three liters of a relatively clear fluid escaped. The cyst was not injured.

Sänger and Klopp also report that after prolonged labour vigorous traction of the half-born child was followed by the escape of large quantities of fluid. The birth of the child was then accomplished. It was found that the abdominal walls were ruptured through a portion weakened from deficient closure of the abdominal plates, and that the fluid which had escaped was largely of peritoneal origin. The presence of the cysts, however, was regarded as the chief cause of the enormously distended abdomen.

Even if the child is born, the cyst may remain as a constant source of danger, and, as in the case reported by Roth, may prove fatal by a twisting of its pedicle. The possible effect of an intra-thoracic cyst is shown by this observer, who found evidence of marked pressure upon the lungs and bronchi. The possibility that the cysts of the abdominal wall may become of considerable size is suggested by the history of the urachus-cysts sometimes found between the muscle and peritoneum and extending from the navel to the pubic symphysis.

The vitelline duct is composed not only of layers of tissue equivalent to those forming the coats of the intestine, but it is also accompanied by bloodvessels. These are the omphalo-mesenteric or vitelline arteries and veins which course along its surface and ramify over the walls of the umbilical vesicle. During the atrophy of the vitelline duct these vessels also become atrophied and eventually disappear with the disappearance of the former. But, as will later be shown, the progressive shrinkage and eventual disappearance of the vitelline duct do not necessitate the atrophy of these vessels.

In his description of the several different degrees of the more or less perfect continuance of the primitive connection between the intestine and the umbilical vesicle, Meckel<sup>1</sup> makes the following statement :—

" Sometimes the umbilical vesicle continues beyond the usual time, and communicates with the ileon by an open canal which the omphalo-mesenteric vessels attend.

" Sometimes only a canal exists; it varies in length, and extends from the same point of the ileon to the umbilicus where it opens, and the omphalo-mesenteric vessels also accompany it.

<sup>1</sup> Meckel, Manual of General, Descriptive, and Pathological Anatomy. Translated from the German into French, with additions and notes, by A. J. L. Jourdan, and G. Breschet. Translated from the French, with notes, by A. Sidney Doane, A.M., M.D., 1832, fil. 289.

"Finally, sometimes, a greater or less prominence exists in this place, a prolongation termed the diverticulum of the ileon; this is often accompanied by the omphalo-mesenteric vessels which float loosely at its extremity, or which are attached to the umbilicus, or to another region of the intestinal canal, so as to form a plexus."

In his article in Reil's *Archiv*, previously referred to, Meckel<sup>1</sup> states that in the examination of embryos older than ten weeks, he has found intact omphalo-mesenteric vessels in the absence of a diverticulum, and concludes therefrom "that in man as well as in animals the remains of the vitelline canal disappear earlier from the intestine than from the vascular system."

The earliest observation of the existence of the omphalo-mesenteric vessels among the lower animals is to be found in Blasius,<sup>2</sup> whom Schröder<sup>3</sup> quotes. They were found by him in the dog, cat, and guinea-pig. Von Siebold, who called Schröder's attention to this observation, also stated that these vessels were very frequently, if not constantly, found in new-born cats and dogs. Schröder immediately verified this statement by the examination of two new-born puppies and a young guinea-pig.

The latest account of the presence of these vessels crossing the abdominal cavity of new-born carnivora as two slender cords is furnished by Allen,<sup>4</sup> as follows:—

"The cords are attached below to the abdominal surface of the umbilicus, and from this they pass forwards and upwards, keeping close together at first, but afterwards separating. The upper end of the one passes into the mesentery of the *ileum* close to its intestinal border; the other passes up to the *meso-duodenum*, and runs into it, close to one of the pancreatic lobes.

"On dissection the posterior cord is found to be connected with the mesenteric artery, the anterior one with the portal vein. I have found the cords in every specimen of new-born cat and dog examined, and frequently in these animals when a week or a fortnight old, and in a few cases at even a greater age. . . . They can be very distinctly seen in the guinea-pig, up to a week old, probably longer, and here also their connections and course are the same as in the kitten, etc. In the young rabbit there is a somewhat similar arrangement, but in it I have not, up to the present, succeeded in finding after birth more than one cord, and it, like the anterior of the two cords in the guinea-pig, is traceable up to the portal vein.

"That the cords are remains of the *omphalo-mesenteric* system of vessels is shown by their connections, the one which is attached to the mesenteric artery being the obliterated *omphalo-mesenteric* artery, the cord which goes to the *portal* vein being the remains of the *omphalo-mesenteric* vein. The correctness of this interpretation is proved by the dissection *in situ* of *intra-uterine* specimens of any of these animals, *e.g.* the foetal guinea-pig, the cords can then be traced out of the body of the foetus, through the umbilicus and into the umbilical vesicle."

Dr. Allen suggests,<sup>5</sup> in explanation of the persistence of these vessels, that

"An adhesion had formed between the allantois and yolk-sac, and that when this adhesion was great an intercommunication was formed between the vessels

<sup>1</sup> Meckel, loc. cit., 444.

<sup>2</sup> Blassius, *De Anatomia Animalium*, 1681.

<sup>3</sup> Schröder, *Ueber die Divertikel-Bildungen am Darm-Kanale*, 1854, 24.

<sup>4</sup> Allen, *The Journal of Anatomy and Physiology*, 1882, xvii. 59.

<sup>5</sup> Loc. cit., 60.

of the two sacs, and that this led to the retention of the *omphalo-mesenteric* trunks long after the cessation of the primitive function."

The disappearance of the vitelline duct while the vessels persist is thus explained :—<sup>1</sup>

"The umbilical intestinal loop is drawn into the abdominal cavity as the rest of the alimentary canal grows; this movement, then, on account of the fixed position of the umbilical vesicle outside, causes the vitelline duct to be stretched so that it very probably soon ruptures, and is then speedily absorbed."

In the development of the vascular system of the embryo there are two sets of vessels, arterial and venous, which are connected with the yolk sac. The original function of both obviously ceases with the establishment of the placental circulation. According to Kölliker,<sup>2</sup> the two primitive *omphalo-mesenteric* arteries which proceed from the aorta to the umbilical vesicle are soon reduced to one. In the fetus of five weeks, this right artery alone remains. The mesenteric artery arises from this, at first as a small branch, but later becomes the main trunk, with the progressive atrophy of that portion between the intestine and the umbilical vesicle.

In like manner two veins are found at the outset, but eventually are reduced to one. This, the left *omphalo-mesenteric* vein, eventually receives a small mesenteric branch from the intestines. With the disappearance of the peripheral portion and the growth of that nearer the heart, the differentiation into the portal and mesenteric veins becomes established.

Although the occasional persistence of the vitelline vessels was apparent to Meekel and his predecessors, as well as to others like Schröder, who followed in the consideration of the remains of the *omphalo-mesenteric* apparatus—renewed attention has been of late years called to this feature.

Hyrtl,<sup>3</sup> in recognition of the fact, refers to an observation by Osiander in 1801, who stated that he found a very fine thread, probably an artery, running from the mesentery to the "side of the peritoneum, where the umbilical artery was lacking."

Ahlfeld<sup>4</sup> showed to the Leipsic Obstetrical Society a preparation from a fetus, consisting of a delicate vessel filled with blood, which could be followed from the umbilical vesicle through the entire umbilical cord, and across the abdominal cavity to the mesentery.

Ruge<sup>5</sup> reports the discovery, in the body of a new-born child, of a cord, the thickness of a linen thread for 2 ctm. and then of hair-like thinness for 1½ ctm., which ran between the mesentery of the small intestine and the tissue around the right umbilical artery, just before its entrance into the abdominal wall. He further describes the projection of a delicate

<sup>1</sup> Loc. cit., 61,

<sup>2</sup> Kölliker, op. cit. 919-921.

<sup>3</sup> Hyrtl, Die Blutgefäße der Menschlichen Nachgeburt, 1870, 6.

<sup>4</sup> Ahlfeld, Archiv für Gynäkologie, 1875, viii. 363.

<sup>5</sup> Ruge, Zeitschrift für Geburtshülfe und Gynäkologie, 1877, i. 7.

thread-like process with a knobbed end from the mesentery near the intestine, and a short distance above the caecum. The statement is then made by him that floating threads with rounded ends may often be found in the mesentery, or near the navel, which are to be attributed to omphalo-mesenteric vessels, or the duct. Immediately after my attention was directed to this point, on examination of the body of a man who died from chronic tuberculosis at the Massachusetts General Hospital, there were found two tuft-like projections from the upper surface of the mesentery, each a half-inch long and about a half-inch apart. They were about two inches distant from that portion of the ileum lying some three feet above the ileo-caecal valve. The peritoneum covering them was normal in appearance, and the mesentery elsewhere was free from all abnormal changes. The peritoneum in the vicinity of the navel was examined, but with negative results. Since then repeated examinations have been made with reference to what might be regarded as vitelline remains, but with indifferent success.

One of the most remarkable instances of a persistent omphalo-mesenteric vessel must be sought for among the earlier observers. The recent discoveries have been made in the bodies of fetuses and new-born children. Spangenberg,<sup>1</sup> however, found in the body of a young man twenty years of age, what he regarded as an open omphalo-mesenteric vessel.

"It could be followed to within a half inch of the navel, where it became a delicate ligament and was lost in the umbilical ring. It descended from the navel, between the epigastric veins, on the posterior surface of the peritoneum, to which it was united by fibrous tissue, to nearly midway between the umbilicus and pubes. Then, leaving the wall of the abdomen as a thin round cord, and crossing its cavity between the coils of small intestine, it passed beneath the latter towards the spine, rather to the left, and emptied into a bifurcation of the main trunk of the superior mesenteric vein. The vessel was wholly free throughout its entire course, nowhere adhering to the intestine, and was enveloped in a fibrous sheath. It was open to within two inches of the navel, and a small quantity of thin blood from the mesenteric vein was admitted as far as its middle. Its coats for three inches from its origin from the mesentery were collapsed like those of any other vein; but from this point onwards it was of denser structure, and very smooth externally. It had no branches and its texture resembled in all respects that of the umbilical vein; which latter was found open through half its course. The appearance of the navel as seen from without did not vary from that of other normally formed umbilical depressions."

The existence of the omphalo-mesenteric vessels, their relation to the omphalo-mesenteric duct, and their occasional persistence entire or in part were well known to Meckel. Their transformation into fibrous cords was likewise familiar to this author. He says,<sup>2</sup>

"Quite recently I found them in a child of three months arising, as usual, from the superior mesenteric artery and vein, running along the entire length of the diverticulum and converted at its end into a solid thread, several inches long and hanging free."

<sup>1</sup> Spangenberg, Deutsches Archiv für die Physiologie, 1819, v. 88.

<sup>2</sup> Meckel, Archiv für die Physiologie, 1809, ix. 439.

He refers to similar threads being found by Otto, Sandifort, and Van Doeverten, and adds:—<sup>1</sup>

“ In one of the last two cases this thread was adherent to the mesentery, in the other to the colon, thus forming a large loop, which might give rise to the most dangerous results.”

This suggestion is evidently based upon a familiarity with the works of Sandifort and Van Doeverten. The former,<sup>2</sup> in his description of an appendix arising from the ileum, states that its end was united to the upper part of the mesentery by a narrow strong thread. He further adds that this formation might have given rise to much disturbance if its infant possessor had lived, especially since a similar band had been found in the bodies of men suffering from ileus. In his catalogue of Van Doeverten's anatomical collection he incorporates the latter's description of a fatal case of intestinal strangulation from a diverticulum and its appendage, probably the first on record. He states<sup>3</sup> that the specimen is one of a sacciform diverticulum, with a blind extremity, from which proceeded an exceedingly tough cord resembling in structure the round ligament of the liver. This crossed the large intestine, ascending on the right beyond the ileo-caecal valve, and became firmly attached to the left side of the caecum somewhat posteriorly. It served as a noose to constrict the intestine between the diverticulum and the colon, producing most of the symptoms of intestinal obstruction and death within forty-eight hours.

Meekel,<sup>4</sup> in his classification of the causes of internal herniaæ, mentions the partial adhesions between parts which should be separated. These may be produced “at the summit of a diverticulum of the ileon, especially by the filament which still exists there, and which is formed by the remnant of the omphalo-mesenteric vessels.” This statement is supported by a reference to the above case of Van Doeverten and to another, that of Monroe, which had occurred in the mean time.

That the latter is not an apt illustration will appear from Monroe's account. He gives<sup>5</sup> the drawing of a specimen coming from a patient in whom “a process grew from the ileum, which passed around, and so greatly compressed a portion of the small intestines as to prove the cause of death.”

A round cord is figured which unites the above-mentioned process, a diverticulum, to the mesentery; the strangulation, however, was the result of a knot formed by the diverticulum about a loop of intestine.

Conspicuous attention having been called to the importance of Meekel's

<sup>1</sup> Meekel, Reil's Archiv, op. cit. 441.

<sup>2</sup> Sandifort, Observationes Anatomico-Pathologicæ, 1777, 124.

<sup>3</sup> Sandifort, Museum Anatomicum, 1793, i. Series iii. 121.

<sup>4</sup> Meekel, Manual, etc., op. cit. iii. 486.

<sup>5</sup> Monroe, The Morbid Anatomy of the Human Gullet, Stomach, and Intestine, 1811, 538.

diverticulum in the production of intestinal obstruction later observers were not slow in adding to the literature of the subject. Eschricht<sup>1</sup> reports a fatal case of strangulation in an old woman, in whom

"The actual diverticulum was about three inches long and a half inch wide at its origin, but became gradually narrowed at its inferior third, and transformed into a solid band about three inches long, which curved backwards towards the mesentery and was inserted not far from the place corresponding with the origin of the diverticulum. . . . ."

"The narrower cord entering the mesentery was evidently merely an apparent continuation of the diverticulum, and I was speedily convinced that it could be only an obliterated omphalo-mesenteric vessel, especially in consequence of the place of its insertion. . . . ."

"The case is thus one declared as possible by Meekel in his Pathological Anatomy, while describing that reported by Sandifort, where incarceration may occur without the attachment of the diverticulum to the umbilicus, where a congenital loop is formed by the origin of the cord at the mesentery and its insertion at the end of the diverticulum."<sup>2</sup>

A case of marked importance in the recognition of the relation between omphalo-mesenteric remains and strangulation of the intestine is reported by Falk.<sup>3</sup> He found in a man, 20 years of age, a diverticulum,  $4\frac{1}{2}$  inches long, 2 feet above the ileo-caecal valve; a solid pseudo-membranous ligament,  $1\frac{1}{2}$  inch long, ran from its apex to the abdominal wall, an inch from the umbilicus. A band united the diverticulum and the mesentery, and this appeared to have caused intestinal obstruction.

Falk states that diverticula of themselves are not of much importance in producing functional disturbance of the intestine.

"But where the umbilical vessels are still adherent, and hang off as threads in the abdominal cavity, they may become agglutinated to the organs of the abdomen, and thus cause volvulus."<sup>4</sup>

The relation of the omphalo-mesenteric vessels or their remains to strangulation was well appreciated by Schröder.<sup>5</sup> He recognizes the occurrence of a band stretching across from the navel to the diverticulum, or to the mesentery in the absence of a diverticulum. In both instances he regards the band as the persistent or obliterated omphalo-mesenteric vessel, and states that

"The insertion in the mesentery is so peculiar, whether it be found in the embryo, infant, or the adult, the observer is obliged to give up the idea of its inflammatory origin, and feels himself almost compelled to recognize the cord as a part of the development of the intestine, particularly as the persistent, more or less completely obsolete, omphalo-mesenteric vessels."<sup>6</sup>

Although recognizing the primitive nature of the cord-like termination of the diverticulum, he accounts for its attachment to other parts of the abdomen than the vicinity of the navel, on the ground of a detachment

<sup>1</sup> Eschricht, Müller's Archiv für Anatomie, Physiologie, und wissenschaftliche Medicin, 1834, 222.

<sup>2</sup> Falk, De Ileo e Diverticulis, Adiecta Morbi Historia, 1835, 18.

<sup>3</sup> Schröder, op. cit., 21 ff.

in intra- or extra-uterine life, and a subsequent adhesion to some part of the peritoneum.

From the time of Schreder's publication to the appearance of Leichtenstern's article on Intestinal Obstruction in Ziemssen's Cyclopaedia, the relation of the omphalo-mesenteric remains to intestinal obstruction became somewhat obscured. Rokitansky<sup>1</sup> asserted that strangulation of the intestine may result when the free end of a diverticulum is adherent, or when the terminal ligament, the obliterated omphalo-mesenteric vessels, becomes adherent to some other part than the umbilicus.

In the consideration of fibrous bands as a cause of intestinal obstruction, Förster<sup>2</sup> says that these are usually the result of peritonitis. The band, however, may be a Meckel's diverticulum adherent to the navel or elsewhere, or a thread representing the remains of the omphalo-mesenteric duct. Klebs<sup>3</sup> treats the matter somewhat more superficially, especially with reference to the nature of the cord which may unite the end of the diverticulum to the navel, mesentery, or caecum. He admits that the cord, being fastened at both ends, may lead to incarceration of the intestines.

Wilks and Moxon,<sup>4</sup> in speaking of malformation of the intestine, say:—

"The diverticulum may extend through the umbilicus of the fetus, and so be divided when the cord is cut; it may then be attached or not to the umbilical opening. Under these circumstances a plastic operation may close the bowel, but afterwards strangulation by the band thus formed has been known to occur."

In the consideration of incarceration it is stated<sup>5</sup> that "in some cases this diverticulum appears as a solid cord, representing, as it were, the vessels that once accompanied the vitelline duct, but sometimes such cords are too high for the vitelline duct."

Jones and Sieveking<sup>6</sup> are still less explicit in referring to the relation between the omphalo-mesenteric remains and strangulation of the bowel.

The adherence of the inflamed peritoneal coat of the diverticulum to neighboring organs is spoken of by Birch-Hirschfeld.<sup>7</sup> "In this instance, and also when the diverticulum is connected with the navel by a solid cord, it may be the cause of intestinal strangulation."

In one of the most recent comprehensive works on Pathological Anatomy, that of Ziegler,<sup>8</sup> there is no mention at all of the importance of omphalo-mesenteric remains as a cause of intestinal obstruction. This author speaks of the etiological importance of new-formed membranes, and thread-like adhesions of pathological origin; but leaves it as a matter

<sup>1</sup> Rokitansky, op. cit., iii. 182.

<sup>2</sup> Förster, op. cit., ii. 110.

<sup>3</sup> Klebs, op. cit., i. 206.

<sup>4</sup> Wilks and Moxon, Lectures on Pathological Anatomy, 1875, 396.

<sup>5</sup> Op. cit. 399.

<sup>6</sup> Jones and Sieveking, Manual of Pathological Anatomy. Payne's ed., 1875, 577.

<sup>7</sup> Birch-Hirschfeld, Lehrbuch der Pathologischen Anatomie, 1877, 853.

<sup>8</sup> Ziegler, Lehrbuch der Allgemeinen und Speziellen Pathologischen Anatomie, 2te Auflage, 1883, ii. 1, 315.

of pure inference, that the cord, which in rare instances unites Meckel's diverticulum to the umbilicus, is of any importance whatsoever.

This omission is all the more striking as forcible attention has been recently called to the importance of the structures in question in connection with intestinal obstruction.

Leichtenstern,<sup>1</sup> in his monograph, includes a brief consideration of the facts already presented in this paper relative to the persistence of the omphalo-mesenteric remains and their pathological importance as a cause of intestinal strangulation. He refers particularly to the lack of knowledge of the congenital nature of the abdominal ligament so frequently regarded as the result of peritonitis, and emphasizes the various conditions whose importance has attracted so little prominence during the twenty years or more since the publication of Schroeder's paper. Attention is called to the observation of Falk, corroborated by the examination of the specimen from another case, which illustrates the attachment of the ligament at three points, the mesentery, the end of the diverticulum, and the umbilicus. The umbilical portion may become atrophied, while that between the intestine and mesentery persists, thus forming a bridge capable of strangulating the loop of intestine which may pass beneath.

The criticism which naturally occurs in the consideration of Leichtenstern's contribution is that he, also, may attach too much importance to the effects of peritonitis. He states<sup>2</sup> that "the end of the diverticulum is usually free or adherent to the mesentery, the small intestine, cæcum, pelvic organs, and anterior wall of the abdomen along the linea alba, or beneath the navel." Later, while speaking of the possible detachment of the omphalo-mesenteric cord from the navel, he says that:—

"The free end of the cord, under favouring conditions, may again become implanted at various parts of the abdomen, and thus give rise to ligaments, which, proceeding from the ileum, one to three feet above the ileo-caecal valve, are inserted in the mesentery, the small intestine, or pelvic organs."

When, however, the detachment takes place at the intestinal end the free portion may likewise become implanted, "and thus give rise to cords extending from (or beneath) the umbilicus to various parts of the abdomen."

Although the thought readily arises that, in consequence of inflammatory processes, the diverticulum may become adherent to various parts of the abdomen, there is very little evidence in its favour. The suggestion is obviously based upon the numerous recorded instances, the resemblance borne by the diverticulum to the vermiciform process, and the well-known frequency of inflammatory adhesions between the latter and adjacent parts.

The recorded instances are all open to the objection so frequently referred to, that their determination often indicates no familiarity with developmental conditions.

<sup>1</sup> Leichtenstern, op. cit., 421.

<sup>2</sup> Loc. cit., 422 ff.

In the Warren Museum, specimen No. 496 of the Improvement Collection has the following record :—<sup>1</sup>

“Strangulation of the intestine by means of a diverticulum, this last arising from the lower end of the ileum, adheres by its blind extremity to the mesentery, and through the ring thus formed a portion of the intestine had passed and become strangulated. The patient died at the Marine Hospital, Chelsea, with all the symptoms of bilious colic, having frequently had similar attacks. Dr. S. D. Townsend.”

The following details may be added to the above description : The diverticulum is  $3\frac{1}{2}$  inches long, and arises from the convex border of the ileum. It is for the most part flattened, two-thirds of an inch wide at its origin, then tapers gradually, till at its extreme end it becomes dilated sufficiently to admit the tip of the little finger. Beneath the peritoneum at the distal end is a circumscribed quantity of fat tissue as large as a raisin. This end of the diverticulum gives no evidence of a preëxisting peritonitis, but is continued directly to the upper surface of the mesentery by means of a gradually tapering cord, one inch in length, and varying in its width from one-quarter to one-eighth of an inch. The last measurement is present at the junction of the cord with the mesentery an inch and one-eighth from the attachment of the latter to the intestine. The cord is composed of peritoneum, fat tissue, and fibrous tissue, and its continuance upwards toward the root of the mesentery, but wholly within the structure of the latter, is suggested by a circumscribed, broad, linear elevation of the peritoneal envelope of the mesentery. A branch of the mesenteric artery was dissected out from its origin near the root of the mesentery, and was found to lie beneath and cause the linear elevation just described. It then entered the tapering cord, uniting the diverticulum and the mesentery. Its course through the cord to the diverticulum was followed out, and its patency demonstrated by the introduction of a fine probe.

Specimen No. 4831 of the museum collection has the following statement :—<sup>2</sup>

“Diverticulum 4 in. long; arose from ileum, 3 feet above caecal valve, and adherent at its blind extremity to the mesentery. Through the ring thus formed convolutions of the small intestine had passed and become strangulated; of a claret colour, and adherent slightly to omentum and parietes. There was about a pint of bloody serum in peritoneal cavity. Man, age, 28, sick 56 hours; attack sudden; pain and tenderness of abdomen and increasing tympanites on second day. Vomited only once after an opium pill. No dejection; bowels free the day before the attack; simple enema the first day, but no cathartic given. Treatment by opiates and stimulants. Symptoms of peritonitis and obstruction in 1877. Dr. Henry J. Barnes.”

<sup>1</sup> A Descriptive Catalogue of the Anatomical Museum of the Boston Society for Medical Improvement, 1847, 142.

<sup>2</sup> MS. Catalogue.

This diverticulum arises from near the mesenteric attachment, and for the greater part of its length has a diameter of one-half an inch. Its distal end is dilated to the size of an English walnut, and is intimately connected with the mesentery, without evidences of peritonitis, two inches from the intestinal insertion of the latter. The mesenteric peritoneum is apparently continued directly over the diverticulum, at the distal end of which a considerable quantity of subperitoneal fat is present. The mesenteric artery is followed downwards, from near the root of the mesentery, toward the attachment of the diverticulum. A half inch from the latter a branch is given off, readily admitting a capillary bougie for two-thirds of an inch. In dissecting out this artery it was followed directly into the subperitoneal fat of the diverticulum where it became too small to trace further.

The direct passage to the diverticulum of a branch of the mesenteric artery, which, in virtue of its size, position, and relation, is to be regarded as a persistent omphalo-mesenteric artery, thus furnishes positive evidence against the theory of an inflammatory origin of the connection between the diverticulum and the mesentery. Negative evidence is afforded, not only by the customary absence from the diverticulum of the appearances of peritonitis, but also by the comparative immunity of the diverticulum from inflammatory disturbances.

Among the numerous specimens of diverticula in the Warren Museum, there is but one, No. 2296, which is the seat of a chronic process. Its record is as follows:—

“A portion of intestine inverted, with a diverticulum. The latter is  $2\frac{1}{2}$  inches in length, was situated five feet and a half from the caecal valve, and shows upon its inner surface three large tubercular ulcers.”

Dr. Beale<sup>1</sup> records an instance of acute peritonitis following perforation of a diverticulum, in the cavity of which were “a cherry stone, the coriaceous covering of several orange-pips, and two masses of very irregular form and tough consistence, resembling in texture the concretions that are often found in the intestines of horses.” Adhesions were present in this case, but the report does not indicate with precision their nature or seat.

An adherent diverticulum is described by Houston,<sup>2</sup> in a manner indicative of the origin. The diverticulum was filled with hard, brittle matter, apparently inspissated feces. The omentum and intestines in the neighbourhood were closely joined to the tumour by adhesions the result of a former inflammatory attack, and the woman had complained for many years before her death of occasional very severe pains in the abdomen.

Mention may also be made of the occurrence of typhoid ulcers in the

<sup>1</sup> Beale, Report of the Proceedings of the Pathological Society of London, 1851-52, 396.

<sup>2</sup> Op. cit. i. 38.

diverticulum. Dr. Galton<sup>1</sup> describes such a case in which perforation occurred terminating fatally.

These few instances of circumscribed peritonitis of the diverticulum, or causes capable of producing it, with the addition of a rare instance of its adherence to the wall of a hernial sac, are the result of a somewhat extensive research into the literature of the subject. A personal experience of more than thirteen years, in connection with the post-mortem examinations at the Massachusetts General Hospital, does not enable me to recall a single instance of adhesive peritonitis in connection with a diverticulum. Although by no means denying the possibility of the inflammatory adherence to various parts of the abdominal wall or its contents of the end of the diverticulum, or of the obliterated omphalo-mesenteric vessel at its end, such an event must be regarded as extremely rare. On the contrary, it is highly probable that most of the cases reported as adherent diverticula owe their condition to the persistence of open or closed omphalo-mesenteric vessels, continued from the diverticulum as a cord or band. This may unite the diverticulum to the abdominal wall near the navel, to the mesentery, or to the intestine, according to the seat and extent of the atrophy of the vitelline vessels.

As the frequent existence of inflammatory adhesions between the diverticulum and neighbouring parts may be disputed, so may the inflammatory adherence of persistent or obliterated omphalo-mesenteric vessels be doubted. Leichtenstern deserves credit for redirecting attention to the almost forgotten, exact, and congenital nature of many of the strangulating bands and cords attributed to the remains of a pre-existing peritonitis. At the same time it seems unnecessary to admit to any considerable extent their detachment and subsequent adherence. The absence of evidences of peritonitis, and an appreciation of the possible points of union from variations in the development of these vessels, will remove much obscurity concerning the origin of the apparent adhesions.

The practical importance of bearing in mind the congenital nature of certain of the causes of acute intestinal obstruction cannot be too earnestly insisted upon. Unfortunately the statistics which are available for the determination of the comparative frequency of the various causes of obstruction are necessarily derived from cases whose record is not sufficiently detailed for our present purpose. At the same time they present a relative value, and the figures are interesting if not important. Haven,<sup>2</sup> Duchaussoy,<sup>3</sup> Brinton,<sup>4</sup> and Leichtenstern<sup>5</sup> have already published comprehensive tables of the causes of intestinal obstruction, and an attempt is here made to compare their results. It is obvious that each suc-

<sup>1</sup> Galton, Transactions of the Pathological Society of London, 1872, xxiii. 103.

<sup>2</sup> Haven, American Journal of the Medical Sciences, 1855; reprint.

<sup>3</sup> Duchaussoy, Mémoirs de l'Académie Impériale de Médecine, 1860, xxiv. 97.

<sup>4</sup> Brinton, Intestinal Obstruction, 1867, 88.

<sup>5</sup> Leichtenstern, op. cit., 528.

*Acute Intestinal Obstruction.*

Approximate relative frequency of the more prominent causes.

	Number of cases included.	Intussusception.	Bands and adhesions.	Twists, knots, and displacements.	Diverticulum.	Volvulus appendix.	Protrusion from tumours, abscesses, or organs.	Diaphragmatic hernia.	Mesenteric hernia.	Omental hernia.	Other internal herniae.
Haven . . .	163	p. c. 39	p. c. 24	p. c. 11	p. c. 6	p. c. ..	p. c. 3	p. c. 5	p. c. 3	p. c. 3	p. c. 6
Duchaussoy . . .	347	39	19	6	6	5	6	..	18	..	..
Brinton . . .	481	54 <sup>1</sup>	17	10	7	3	..	..	62	33 <sup>2</sup>	..
Leichtenstern . . .	1134	39	9	6	6	4	4	19	..	54 <sup>3</sup>	75

sive writer has probably included all the cases of his predecessors, although his method of tabulating varies materially. In consequence of this diversity of arrangement, considerable, even wide, differences in the result arise. This is particularly true with reference to the frequency of obstruction from bands and adhesions. It is from this series that it is important to eliminate in the future those which may be due to congenital causes, as obliterated or patent omphalo-mesenteric vessels, and those which are the result of inflammatory conditions, dislocated organs, or pedunculate tumours.

It results, from a comparison of the above statistics, that next in importance to intussusception as the cause of acute intestinal obstructions are bands and adhesions. In a valuable paper published by Fagge,<sup>6</sup> and based upon the examination of the records of 4000 autopsies at Guy's Hospital, from 1854 to 1868, it appears there were 54 cases of intestinal obstruction, the chronic as well as the acute varieties being included. Among these were 7 of intussusception, 6 of volvulus, and 5 each from a diverticulum and from bands. The importance of the bands and adhesions is all the more evident when it is appreciated that in the table above presented this group should include many recorded instances of omental if not

<sup>1</sup> Brinton gives 43 per cent. of intussusception in his table of 600 cases of intestinal obstruction by this lesion, bands, adhesions, diverticula, or peritoneum external to the bowel, strictures (including a few tumours) involving the intestinal wall, and torsion of the bowel on its axis. Op. cit. 38.

<sup>2</sup> Ruptured mesentery.

<sup>3</sup> Other peritoneal and omental lesions.

<sup>4</sup> Omental incarceration.

<sup>5</sup> This percentage includes cases of mesenteric incarceration and compression, incarceration in abnormal openings of organs, in rings from adhesions, as well as internal herniae.

<sup>6</sup> Fagge, Guy's Hospital Reports, 3d series, 1869, xiv. 272.

mesenteric strangulation, as well as of incarceration in rings from adhesions between organs. It is not intended to suggest that, in most of the cases of obstruction from bands and adhesions, the latter are the result of developmental conditions. It is obvious, however, from what has already been stated, that persistent vitelline vessels, closed or open, may be found as cords or bands between the umbilical region of the anterior abdominal wall and the intestine or mesentery, or both; that they may be connected with these parts near the stomach, as well as at the lower portion of the ileum. Furthermore, a band or cord of similar origin may connect a diverticulum with the intestine or with the mesentery. Finally, the band may be attached at both ends to the mesentery, and yet be of like congenital origin.

In this connection, the figures given by Brinton<sup>1</sup> relative to the insertion of bands are of interest. This author states that "their attachment is generally (75 per cent.) to mesentery or omentum (as 4 to 1) . . . often (34 per cent.) by one end to the free margin (or some other part) of the bowel . . . Rarely (1 case in 5) are they fixed to the large intestine; and it is still more (thrice as) infrequent for them to unite two points of bowel."

Duchaussoy<sup>2</sup> states, that of 48 cases of strangulation from bands and adhesions, the right side of the abdomen was the seat in 30 cases; and in most instances between the umbilicus and the right iliac fossa. It is in this part of the abdomen of all others in which the persistent omphalo-mesenteric remains are found, since it is here that the lowermost portion of the ileum is situated. The suggestion is thus readily entertained, that of these cases collected by Duchaussoy, several if not many of the bands were of congenital origin, and the examination of the original articles as well as of his abstracts makes such a suggestion more than justified.

The above consideration seems to warrant the following conclusions:—

1. Bands and cords as a cause of acute intestinal obstruction are second in importance to intussusception alone.
2. Their seat, structure, and relation are such as frequently admit their origin from obliterated or patent omphalo-mesenteric vessels, either alone or in connection with Meckel's diverticulum, and oppose their origin from peritonitis.
3. Recorded cases of intestinal strangulation from Meckel's diverticulum, in most instances at least, belong in the above series.
4. In the region where these congenital causes are most frequently met with, an occasional cause of intestinal strangulation, viz., the vermiciform appendage, is also found.
5. It would seem, therefore, that in the operation of abdominal section for the relief of acute intestinal obstruction not due to intussusception and in

<sup>1</sup> Brinton, op. cit., 69.

<sup>2</sup> Op. cit., 318.

the absence of local symptoms calling for the preferable exploration of other parts of the abdominal cavity, the lower right quadrant should be selected as the seat of the incision. The vicinity of the navel and the lower three feet of the ileum should then receive the earliest attention. If a band is discovered, it is most likely to be a persistent vitelline duct, *i. e.*, Meekel's diverticulum, or an omphalo-mesenteric vessel either patent or obliterated, or both these structures in continuity. The section of the band may thus necessitate opening the intestinal canal or a blood-vessel of large size. Each of these alternatives is to be guarded against, and the removal of the entire band is to be sought for, lest subsequent adherence prove a fresh source of strangulation.

The chief practical conclusion thus reached in this article is essentially the same as that of Nélaton.<sup>1</sup> This surgeon advised that the incision through the abdominal wall for the relief of intestinal obstruction should be made a little above Poupart's ligament, preferably in the right side. The knuckle of intestine first presenting was to be united to the edges of the wound and incised, an intestinal fistula being thus established. His recommendation was based upon the applicability of this operation, enterotomy, to all cases of intestinal obstruction, since it is usually impossible to make a differential diagnosis of the causes of ileus. The place was selected since a loop of intestine above the seat of obstruction is likely to be found in this part of the abdomen, and it is also likely to be so far from the stomach that a sufficiency of intestine for digestive purposes will be left intact.

The due appreciation of the relative frequency of congenital causes of intestinal obstruction in the region recommended by Nélaton as the place of operation adds force to his arguments. The operation of enterotomy in the best favoured position is still at hand, provided the above causes of obstruction are not found.

The notes of the following case, kindly given me by Dr. John Homans, of Boston, in whose practice it occurred, illustrate several of the points treated of in this paper.

A man, 21 years of age, met with a severe fall Feb. 8, 1884. He had always been healthy with the exception of a congenital umbilical sinus, which was vaguely supposed to communicate with the intestine. His mother was confident that portions of food (seeds and the like), after being swallowed, had escaped at times from the sinus, and that the latter had been closed since October, 1882. For the past three months he has not been obliged to wear a protecting pad.

Four days after the fall he was seen by Dr. John O. Dow, of Reading, Mass., who found him suffering from absolute intestinal obstruction, tympanites, tenderness, and pain. Three days later, a week after the accident, frequent vomiting of an offensive, so-called fecal, matter took place. Dr. Homans was summoned in consultation after another interval of three days, and found the patient vomiting every few minutes an

<sup>1</sup> Nélaton, L'Union Médicale, 1857, xi. Nos. 89, 91, 93.

exceedingly offensive brown fluid. The abdomen was distended, tympanitic, and tender. The eyes were bright, and the countenance intelligent. Pulse feeble, about 130.

A dark-coloured urine was drawn from the bladder, and a director introduced into the sinus. A little fecal matter seemed to escape. The opening was enlarged laterally, especially to the left, sufficiently to admit the finger. The incision may have been an inch and a half long, and the finger entered the peritoneal cavity. No obstruction was felt near the umbilicus within reach of the finger. A loop of intestine was seized, sewn to the skin, and an opening, about a half inch in length, was made through its wall. No fecal or intestinal contents escaped till after the junction was completed, when an offensive, brownish, fluid material and gas were freely discharged.

The patient remained under the care of Dr. Dow, who from time to time reported his condition to Dr. Homans.

On the day following the operation the temperature was  $100.4^{\circ}$ ; the pulse 108. The vomiting had ceased, and there was some relish for food. Occasional twinges of pain in the right groin were complained of. There was but little abdominal distension, and Dr. Dow was able to detect a circumscribed enlargement in the vicinity of the ileo-caecal valve. Two days later the temperature was normal; pulse 108. The swelling and tenderness in the groin were much diminished, and there were no twinges of pain. Solid food was desired. On the next day, Feb. 22, the temperature was  $96.2^{\circ}$ ; the pulse 120. Restlessness, distress in the back, and ringing in the ears were the prominent symptoms, and were attributed to insufficient nourishment. Injections of beef-tea were given, and were followed by marked relief, the pulse falling to 108, and the temperature rising to the normal. His strength gradually failed, however, notwithstanding food was given by the mouth and rectum. The temperature became persistently lower, and the pulse weaker with increasing frequency. His death took place Feb. 25, one week after the operation. On the day preceding a passage from the bowels occurred, although Dr. Dow was of the opinion that the contents of the stomach never passed beyond the intestinal fistula.

An autopsy was made twenty-six hours after death by Dr. G. E. Putney, of Reading, who has furnished the following interesting report:—

He found the body considerably emaciated and the abdomen flat. A probe inserted into the congenital opening passed downwards, forwards, and to the right, at an angle of  $40^{\circ}$  with the median line.

The parietal peritoneum was glistening, of a dark, reddish-slate colour. Its bloodvessels were prominent, especially around the umbilicus, within a radius of four inches. There was no lymph. The small intestine was of a very dark, drab-red colour. The large intestine moderately injected and the colon about two-thirds the normal size. The artificial opening into the intestine was fifty-two inches below the pylorus. Its edges were thickened, ragged, and sloughing, and had failed to unite with those of the abdominal wound.

A diverticulum four inches long and a half inch in diameter arose from the ileum four feet above the ileo-caecal valve, and extended to the umbilicus. The ileum below its origin was three-fourths of an inch in diameter. The tissues of the diverticulum appeared normal with the exception of the muscular coat of the distal three-fourths of an inch, which was thrice the normal thickness. A tendinous cord the size of a

darning needle and four inches long proceeded from the mesentery along the diverticulum, and became lost in the tissue surrounding the umbilical opening. In its course along the diverticulum it appeared as if ensheathed.

The contents of the small intestine resembled a dark pea soup; those of the large intestine were pulaceous, resembling yeast. There was no evidence of an existing constriction at the time of the autopsy.

There seems to be no reasonable doubt that the above case is one of intestinal obstruction from persistent omphalo-mesenteric remains. The band is of exceptional interest as composed throughout of both vascular and intestinal portions, although evidence of patency of the former is not recorded. The autopsy gives no evidence of the manner in which the obstruction occurred, but it is known that a coil of intestine may become looped or knotted over a cord or band. It may also become twisted, and be prevented from unwinding by the pressure of the distended intestine. The operation was effectual in relieving the obstruction, presumably by removing the pressure caused by the distended intestine, and thus permitting the bowel to right itself.



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